The NGST Integrated Science Instrument Module

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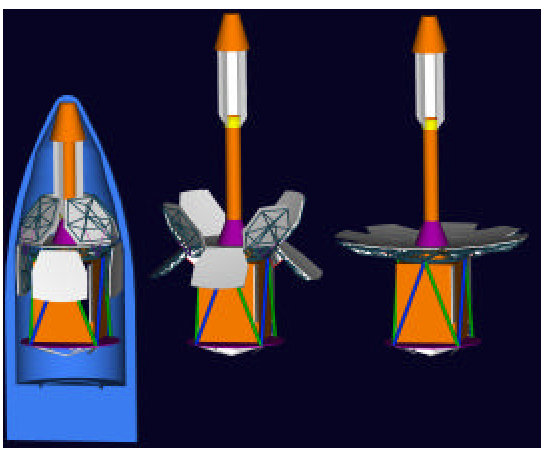
ABSTRACT

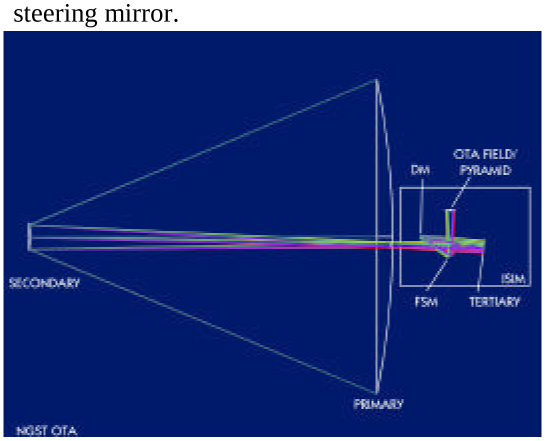
An Integrated Science Instrument Module (ISIM) design is under ongoing development for integration with the "Yardstick" (see Bely et al. these proceedings) and other NGST 8 m architectures that are intended for packaging in an EELV or Ariane 5 meter class fairing. The goals of this activity are to: [1] demonstrate mission science feasibility, [2] assess ISIM engineering and I&T feasibility, [3] asses ISIM cost feasibility, [4] identify ISIM technology challenge areas, [5] identify ISIM/NGST interface constraints, and [6] enable smart customer procurement of the ISIM. Ongoing progress can be monitored at: http://www701.gsfc.nasa.gov/isim/isim.htm

1. INTRODUCTION

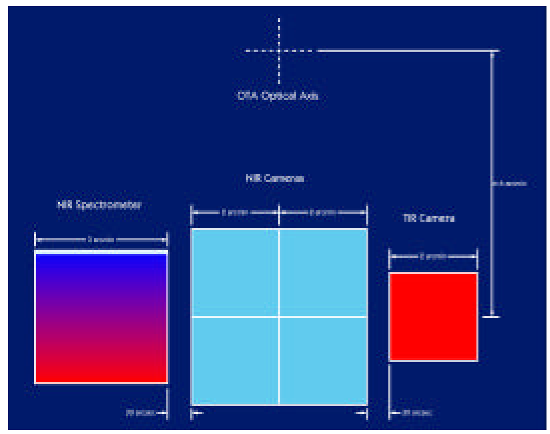
The ISIM occupies a 2.5 x 2.5 x 3.3 m volume behind the telescope primary mirror as shown

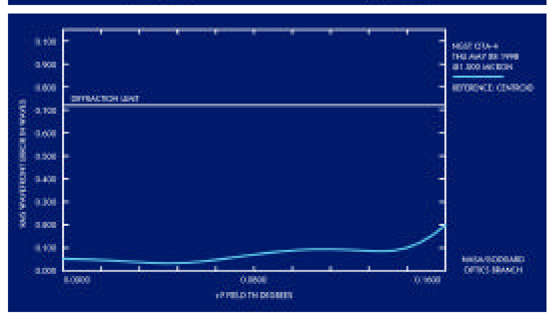


above. The yardstick telescope includes an on axis optics train within the ISIM consisting of a tertiary mirror, deformable mirror, and fast steering mirror.



As a consequence, the instruments are located 6 arc-min off axis. However, as a result of the three mirror telescope design, excellent image quality is achieved in this configuration.

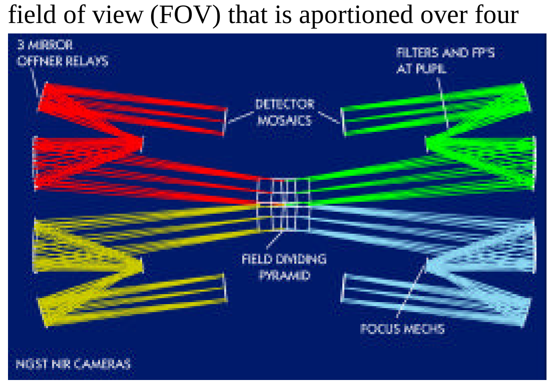




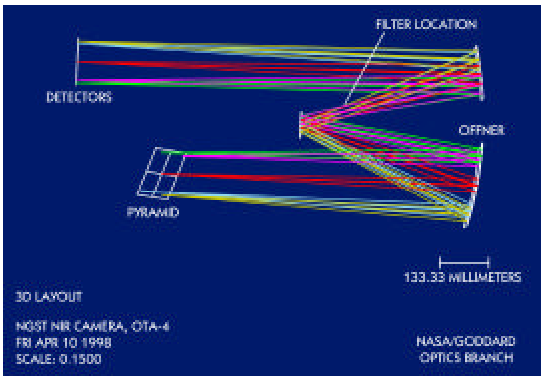
Our study has focused on two baseline instruments: a wide field camera and a multi-object spectrometer covering 0.6 – 5.3 µm, and an optional instrument consisting of a combined camera/spectrometer covering 5 – 28 µm.

2. THE NEAR-INFRARED CAMERA

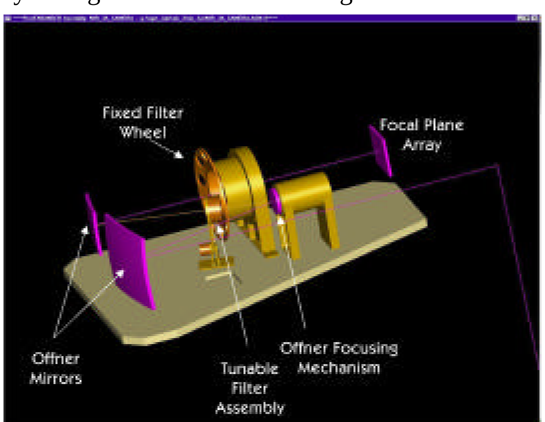
The near-infrared camera has a 4 x 4 arc-min field of view (FOV) that is aportioned over four

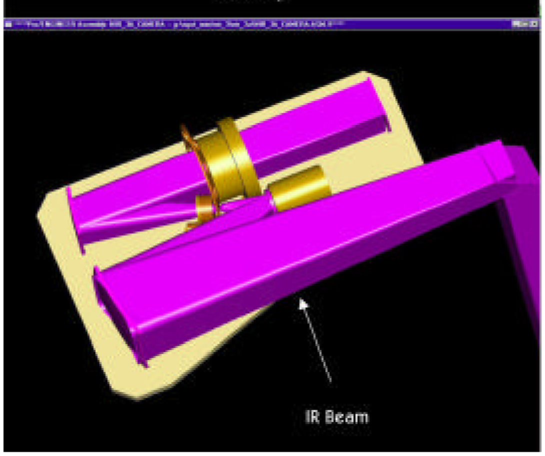


similar camera modules by a field dividing pyramid mirror. Each module covers a 2 x 2 arc-min FOV, using a simple optics design for maximum sensitivity. Each camera module contains an Offner relay that provides an accessible pupil for filters and stray light control. Each Offner secondary mirror is mounted on a focus mechanism to provide parfocality among the modules.

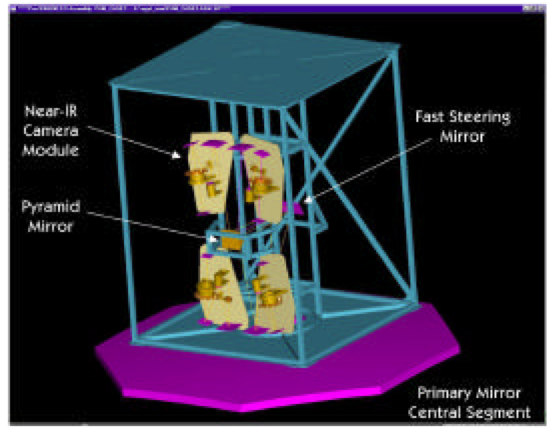


Filter requirements are met using wheel mounted broad-band (2-5%) filters in combination with R = 50 - 200 tunable filters that are rotated into the beam when narrow-band imaging or hyperspectral image data cubes are desired. The tunable filters consist of scanning etalons used in 1st or 4th order with low phase dispersion reflectors that illuminate the focal plane arrays (FPA) with a single order of interfearance yielding a monochromatic image.



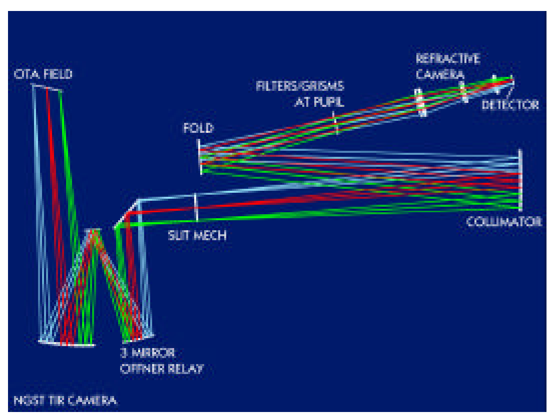


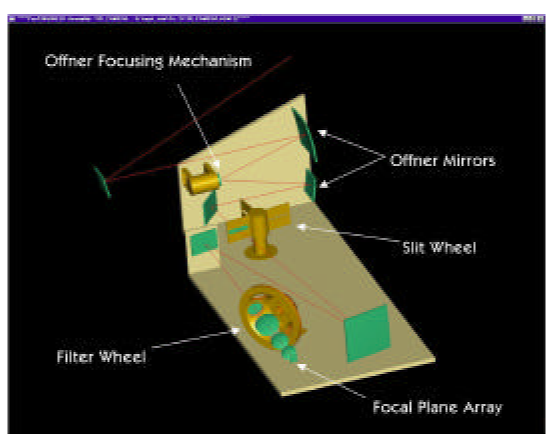
The four wide field camera modules integrate into the ISIM structure in a modular fashion.

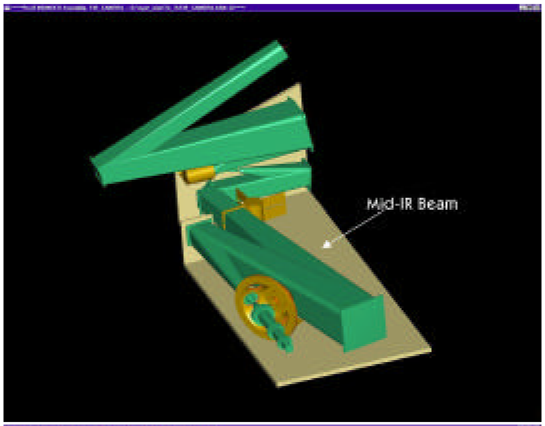


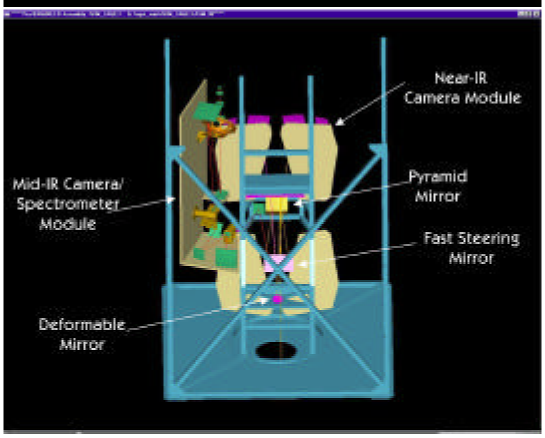
3. THE MID-INFRARED CAMERA/SPECTROMETER

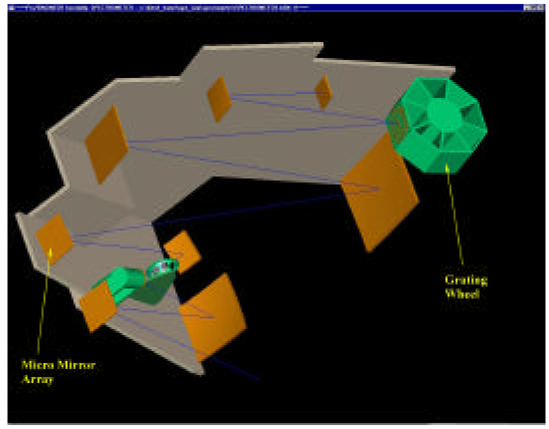
The mid-infrared camera employs a focusing Offner fore optics assembly similar to the near-infrared camera. A slit selecting mechanism is used to provide several slit widths for cross dispersed grism spectroscopy at $R \sim 10^2$ and 10^3 . An open position on this mechanism provides a direct imaging mode. Nested conical filter wheels carry filters, grisms, and a cross disperser. An alternate design employing a refective camera is also under development.

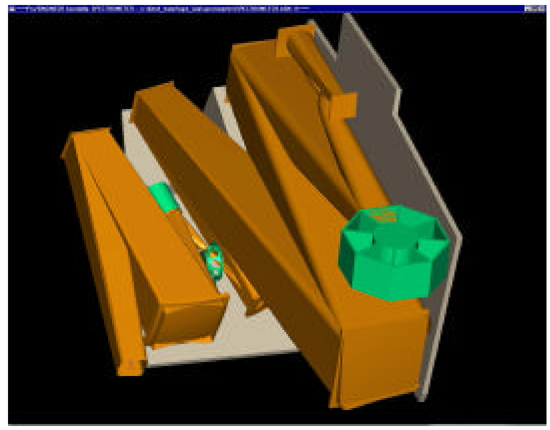


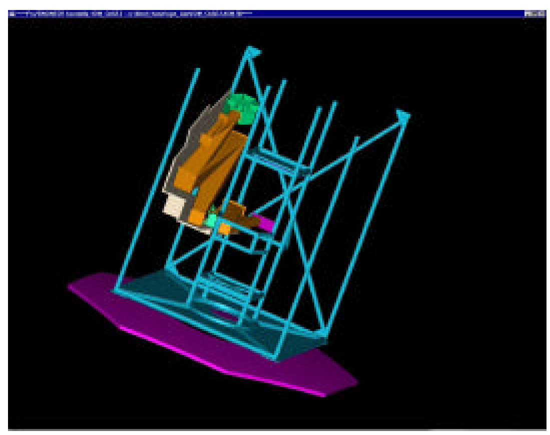






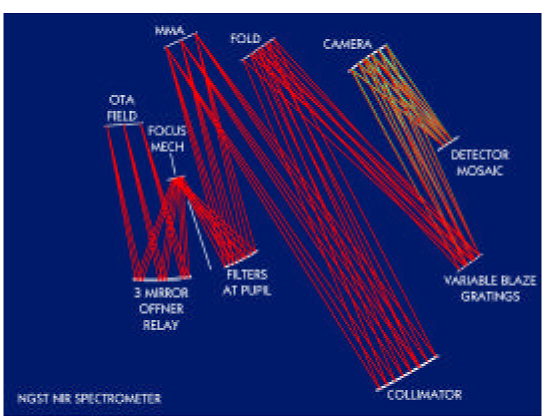






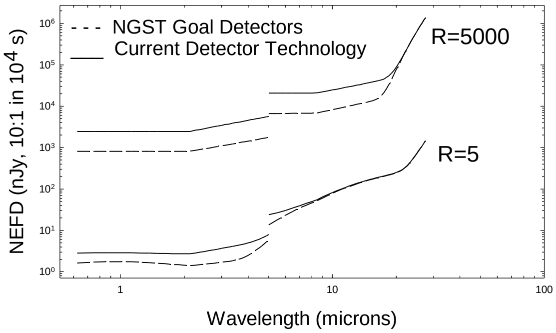
4. THE NEAR-INFRARED MULTI-OBJECT SPECTROMETER

The multi-object spectrometer (MOS) employs a focusing Offner relay similar to the other instrument modules. Aperture control that is optimized for wide field sparse target applications is provided by a MEMS micro-mirror array (MMA) reflective slit mask located at the relayed telescope field. The large format (2048 x 2048) MMA mosaic employs 95 µm pixels on 100 µm centers. Each pixel can be independently rotated through 10 degrees of arc via electrostatic forces to divert light into or away from a conventional grating spectrometer of R ~10^2 and 10^3.

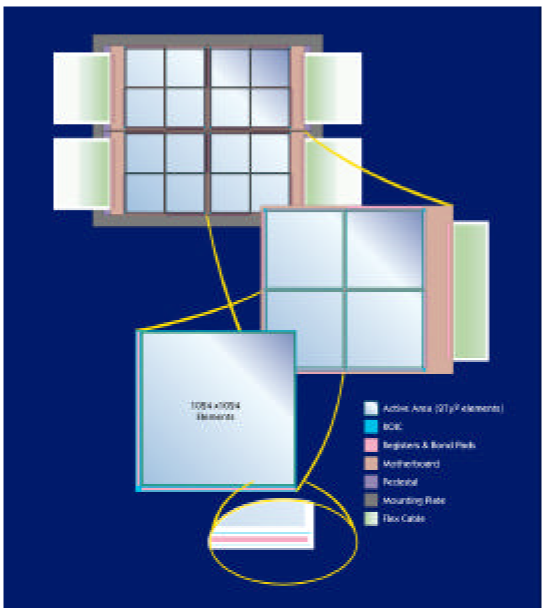


5. DETECTORS

Although a reduction in ISIM complexity and enhanced thermal performance can be garnered through a new generation of 2048 x 2048 near-infrared (e.g. InSb, HgCdTe) arrays and 1024 x 1024 mid-infrared (e.g. Si:As, Si:Ga) arrays, we find that DRM science objectives can be enabled with present technology. As a consequence, detector performance stretch goals are enhancing rather than enabling technology developments for NGST.



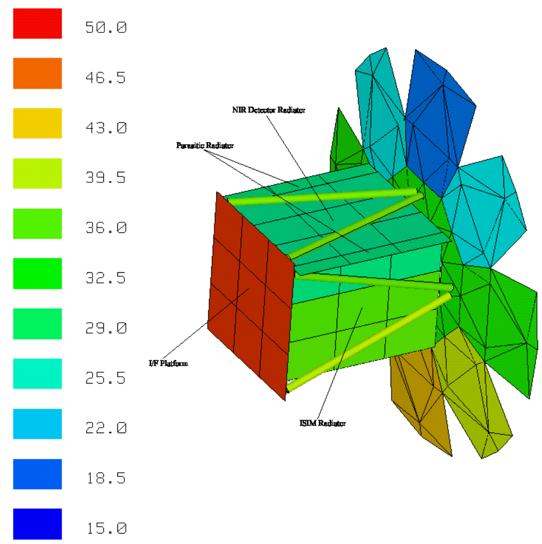
However, manufacturing technology development is required to enable fabrication of near-infrared 4096 x 4096 FPA mother board assemblies needed by the wide field camera and MOS spectrometer.



6. ISIM THERMAL REQUIRMENTS

Cryogenic cooling of the ISIM is required to supress optics thermal emission and FPA dark current. We find that ISIM and OTA optics temperatures in the range of 30-40 K can be achieved with the "Yardstick" architecture. This temperature range will enable Zodical background limited performance at wavelengths as long as 15 µm.

Cooling for five 4096 x4096 InSb FPAs can be achieved with radiative cooling alone. However, we find that within baseline FPA assumptions, active cooling is required to enable optional instruments beyond the two near-ir baseline instruments – regardless of whether these optional instruments utilize optical, near-ir, or mid-ir FPAs.



We find that this additional cooling can be met with commercially available turbo-Brayton cooler technology.

7. SUMMARY

We find that a 20 cubic meter ISIM package can be reasonably packaged within the EELV version of the "Yardstick" architecture. A discrete instrument module layout involving 3-4 major instruments is feasible. Passive cooling is feasible for an ISIM consisting of two near-ir instruments that utilize a total of five 4096 x 4096 InSb FPAs. Active cooling is required for any additional instruments or for OTA temperatures > 35 K. A fully redundant 30 K and/or 6 K active cooler can be accommodated within ISIM package and power constraints.